



US008111853B2

(12) **United States Patent**  
**Isvan**

(10) **Patent No.:** **US 8,111,853 B2**  
(45) **Date of Patent:** **Feb. 7, 2012**

(54) **DUAL MODE EARPHONE WITH ACOUSTIC EQUALIZATION**

(75) Inventor: **Osman Kemal Isvan**, Aptos, CA (US)

(73) Assignee: **Plantronics, Inc**, Santa Cruz, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 880 days.

(21) Appl. No.: **12/170,716**

(22) Filed: **Jul. 10, 2008**

(65) **Prior Publication Data**

US 2010/0008528 A1 Jan. 14, 2010

(51) **Int. Cl.**  
**H04R 1/20** (2006.01)

(52) **U.S. Cl.** ..... **381/337; 381/309; 381/328; 381/338; 381/345; 381/347**

(58) **Field of Classification Search** ..... None  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

6,704,429 B2 \* 3/2004 Lin ..... 381/380  
7,349,550 B2 \* 3/2008 Oliveira et al. .... 381/380

2002/0080990 A1 \* 6/2002 Lin ..... 381/380  
2009/0022343 A1 \* 1/2009 Van Schaack et al. .... 381/309  
2009/0086159 A1 \* 4/2009 Jannard ..... 351/158  
2009/0101433 A1 \* 4/2009 Stiehl et al. .... 181/129  
2010/0142726 A1 \* 6/2010 Donaldson ..... 381/93  
2010/0246879 A1 \* 9/2010 Sahaan et al. .... 381/380  
2011/0103609 A1 \* 5/2011 Pelland et al. .... 381/74

\* cited by examiner

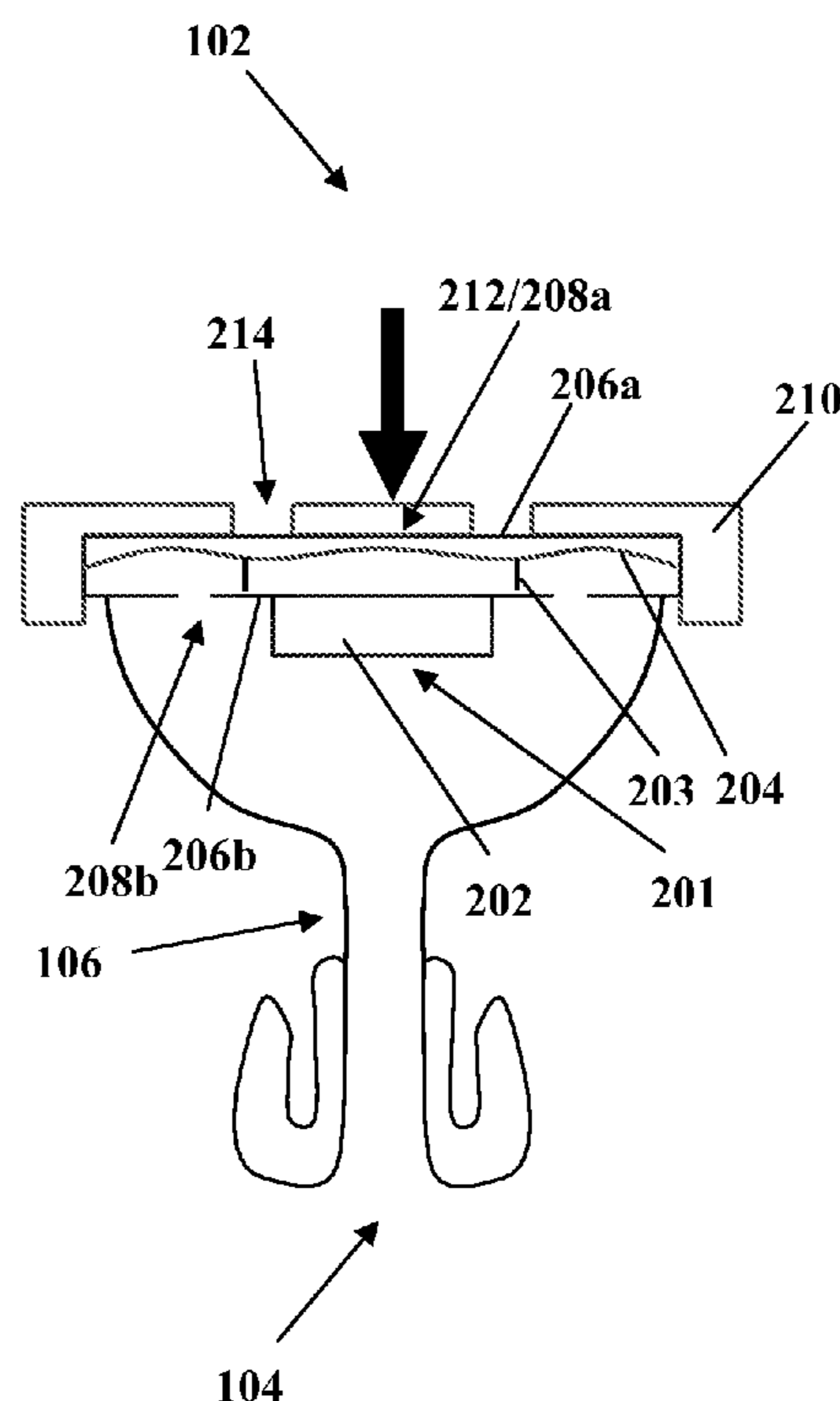
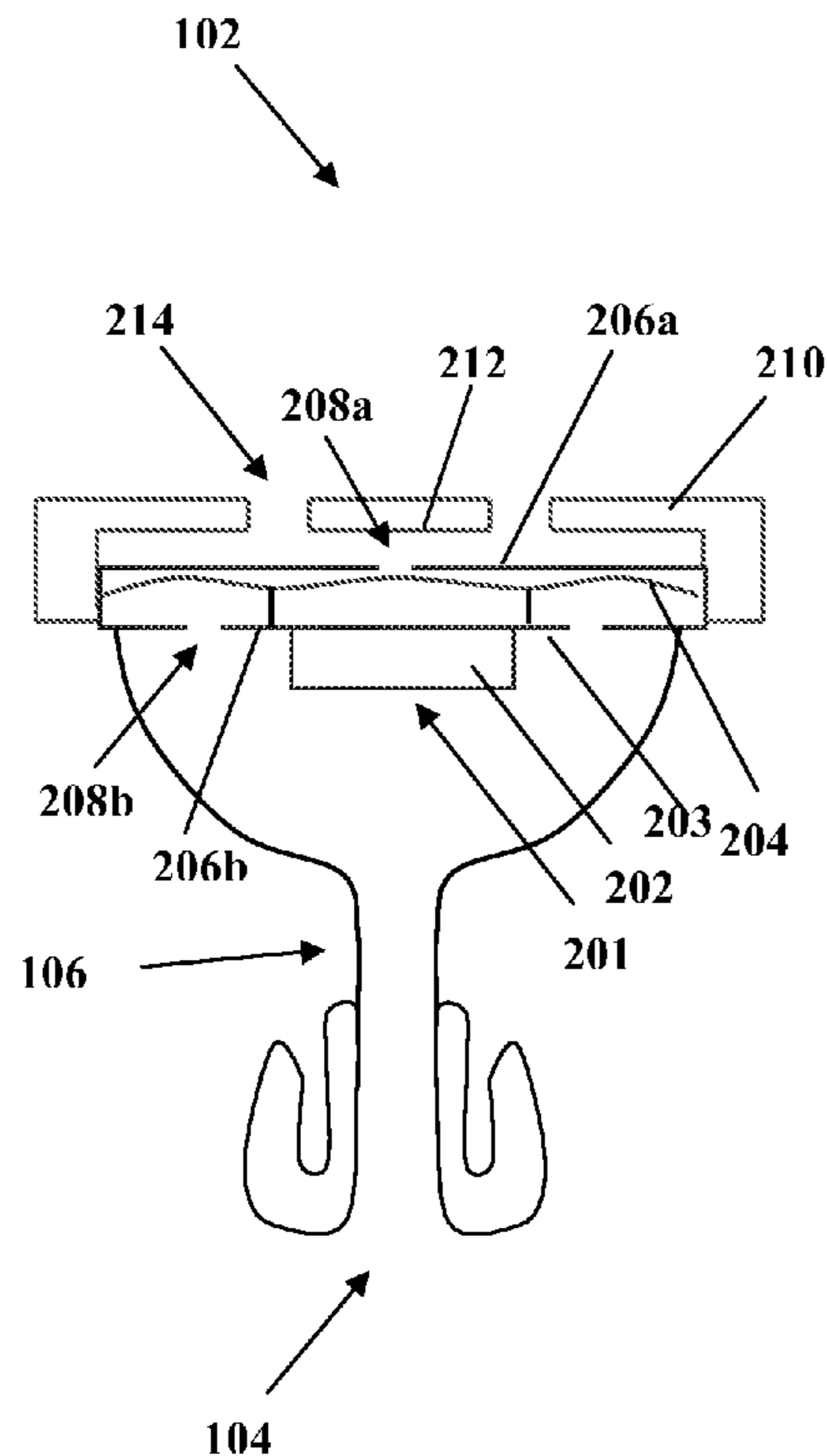
*Primary Examiner* — Marlon Fletcher

(74) *Attorney, Agent, or Firm* — David S. Park; Andre Tacdiran

(57) **ABSTRACT**

In one embodiment, a dual-mode earphone is provided, comprising a first earbud including a speaker with a diaphragm and at least one acoustic port in front of the diaphragm, and a cap in front of the speaker. The speaker or the cap is configured to move relative to the other for opening and closing the acoustic port in one embodiment and a movable seal is provided in another embodiment. The earphone further includes a second earbud housing operably coupled to the first earbud opposite the speaker. A method for providing acoustic equalization in a dual-mode earphone is also disclosed.

**20 Claims, 6 Drawing Sheets**



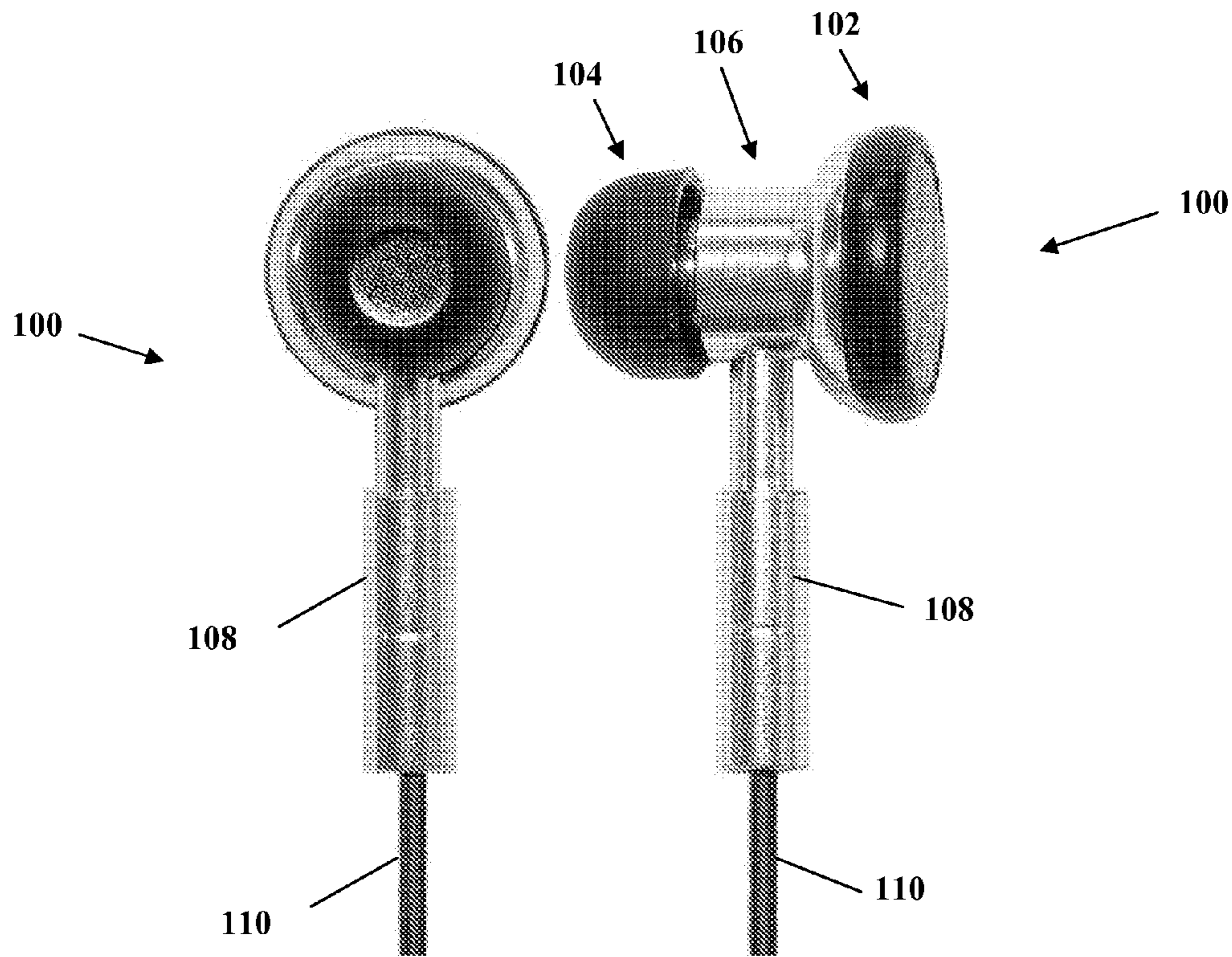


FIG. 1A

FIG. 1B

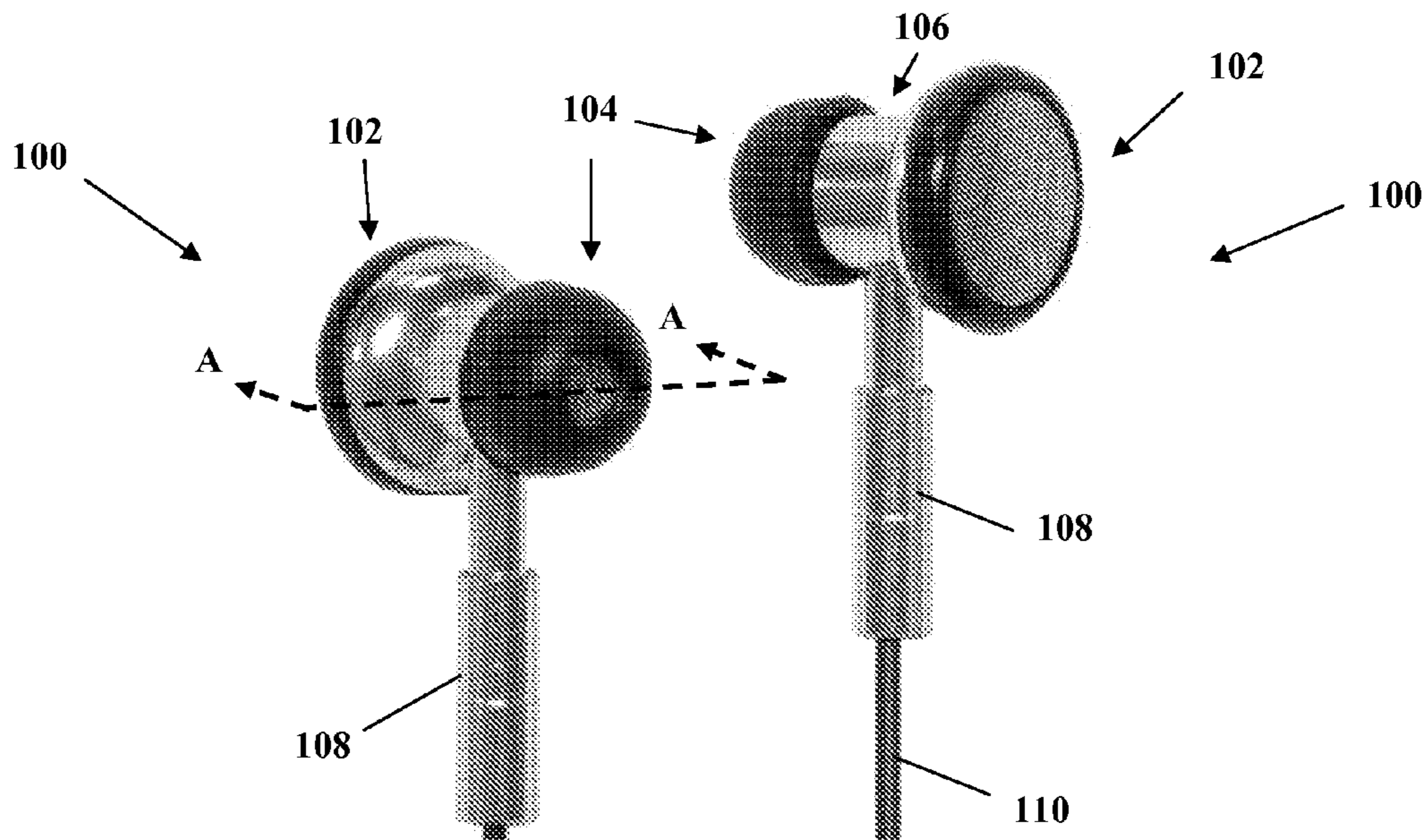


FIG. 1C

FIG. 1D

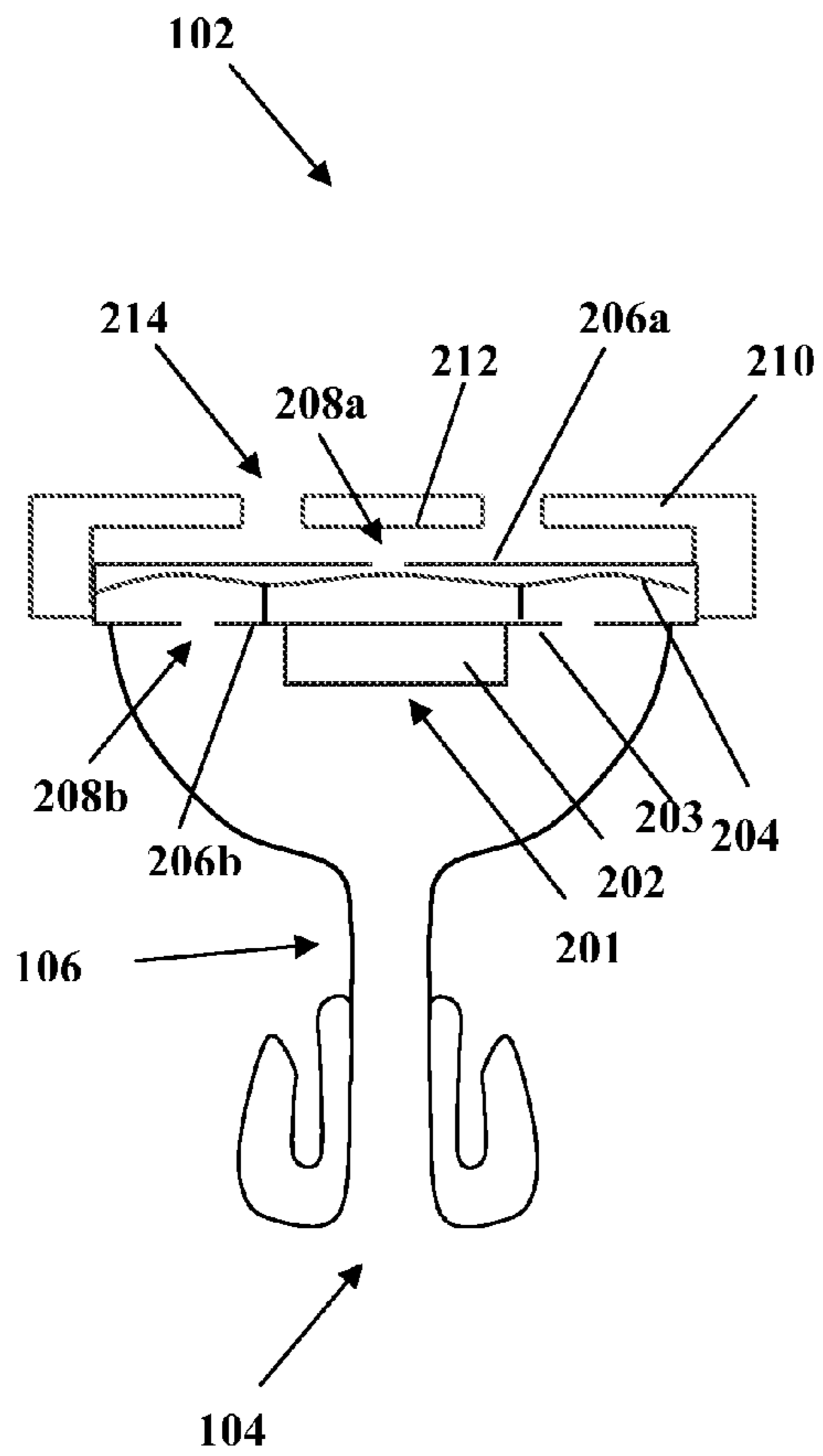


FIG. 2A

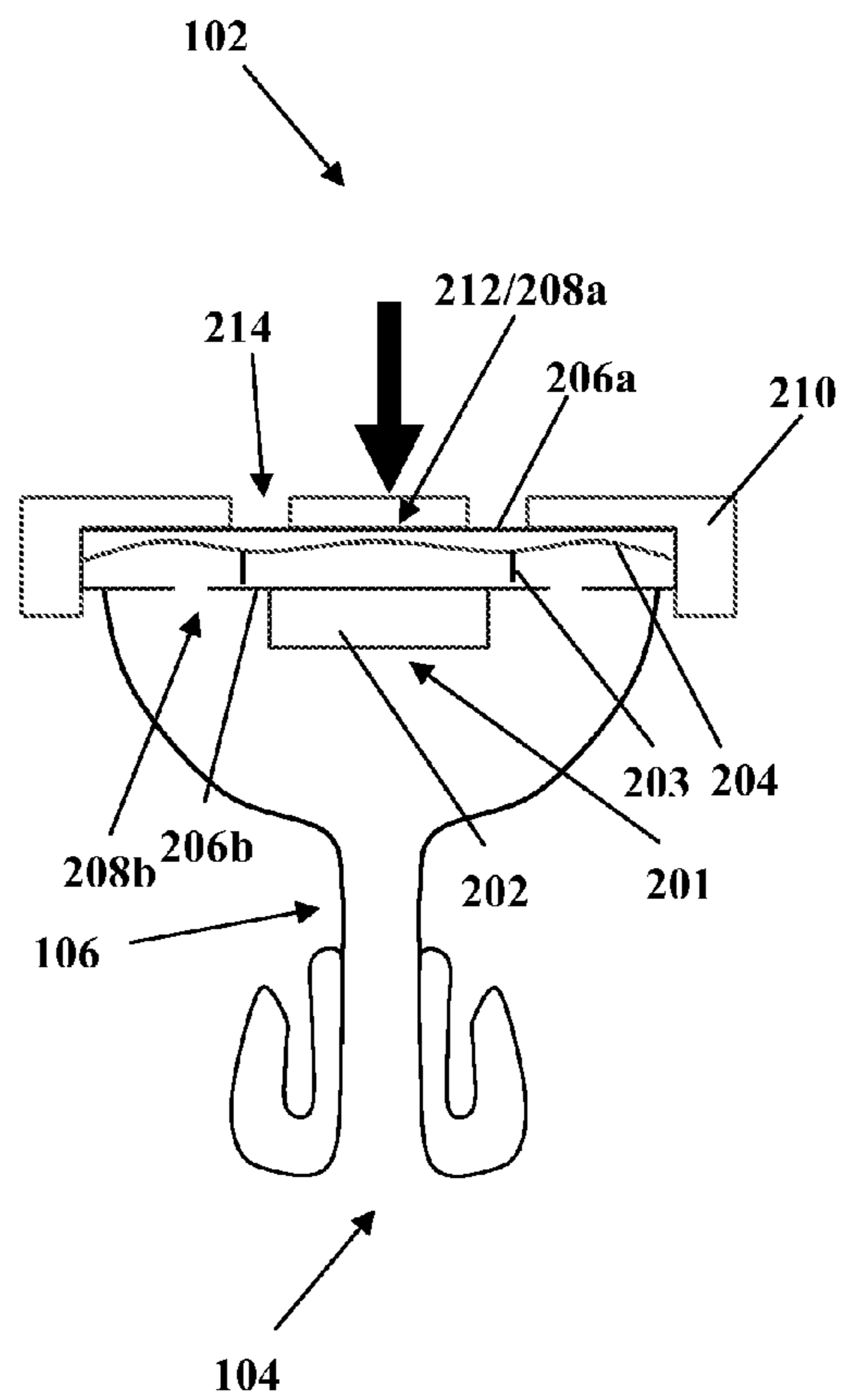


FIG. 2B

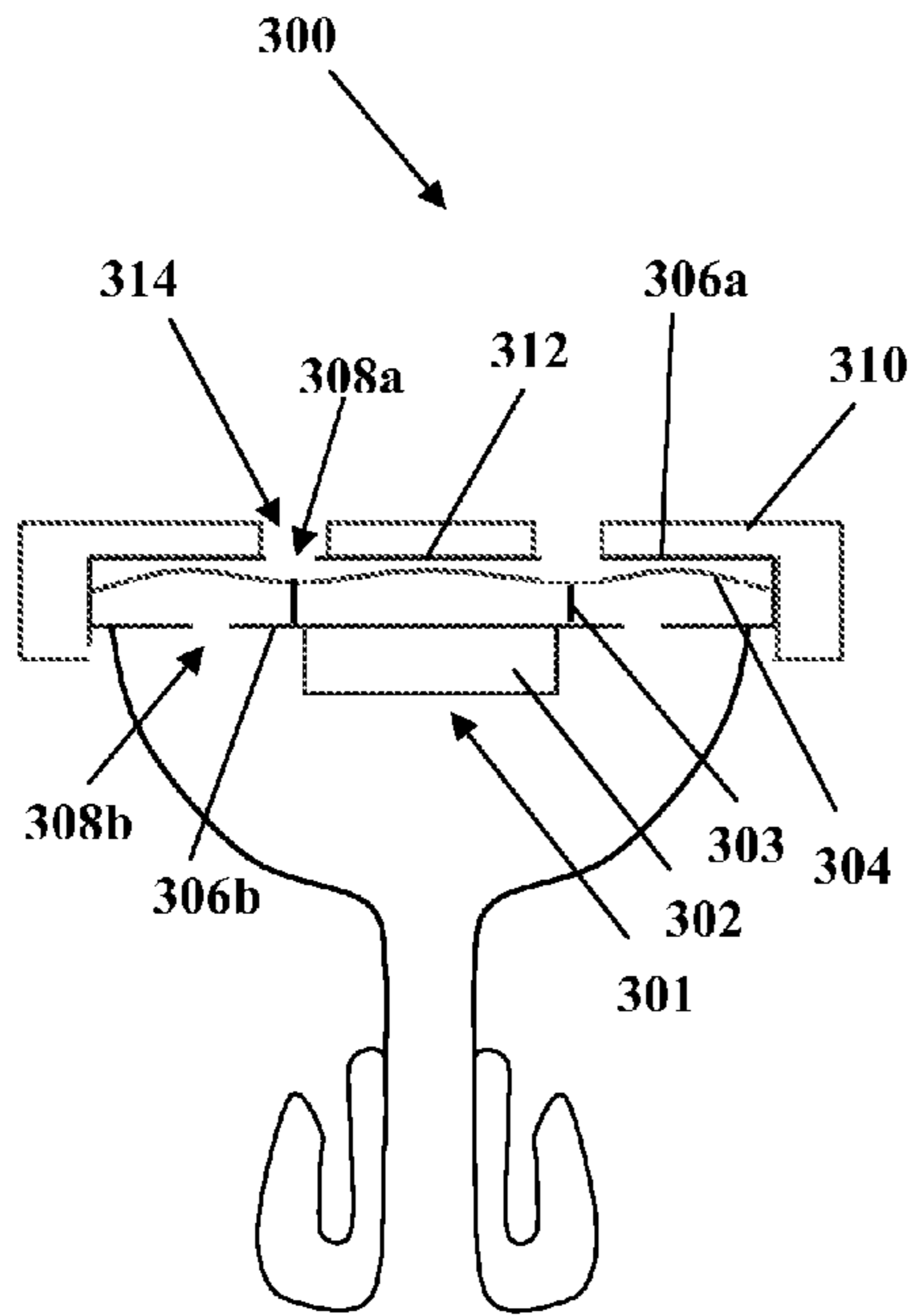


FIG. 3A

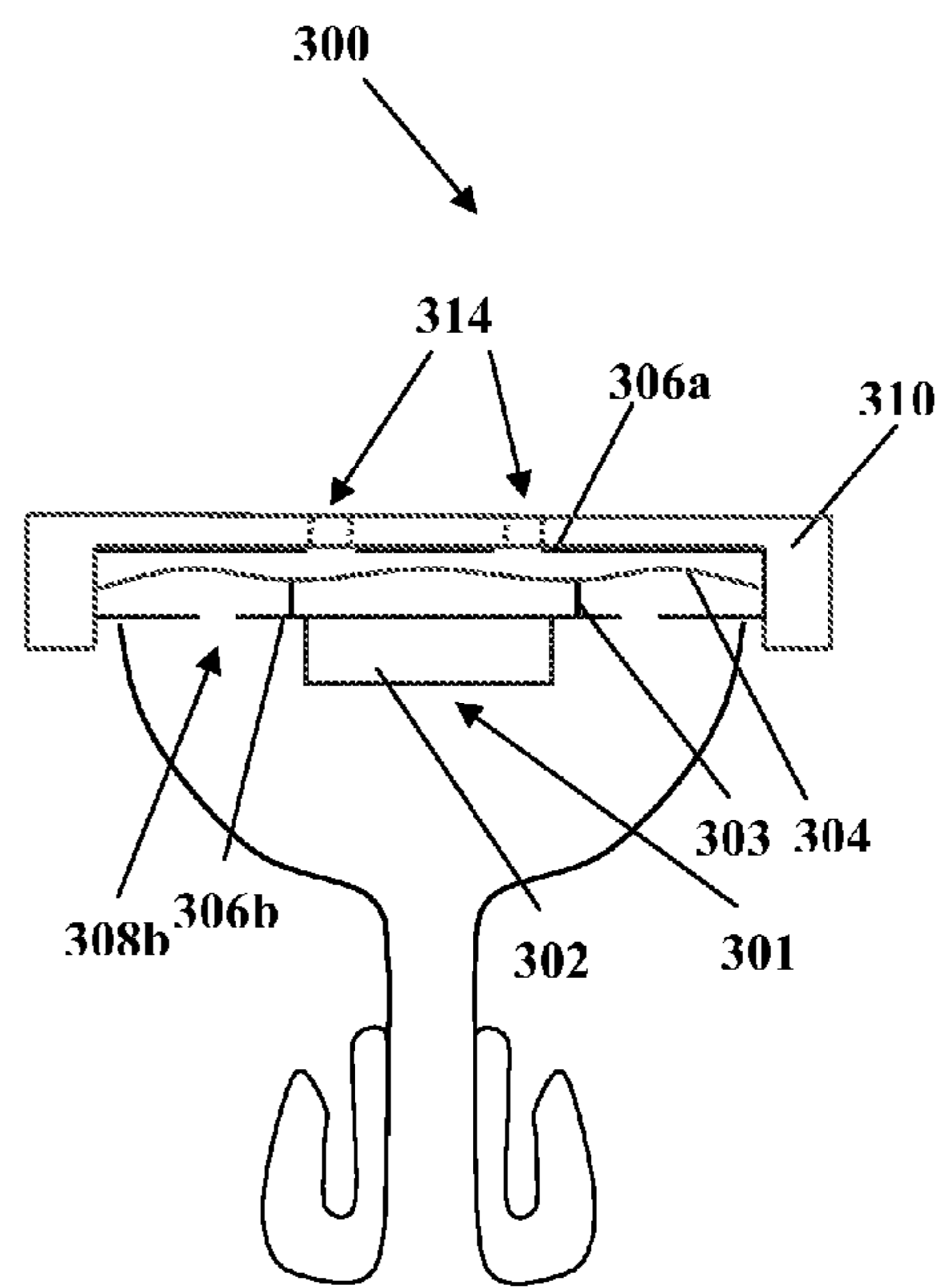


FIG. 3B

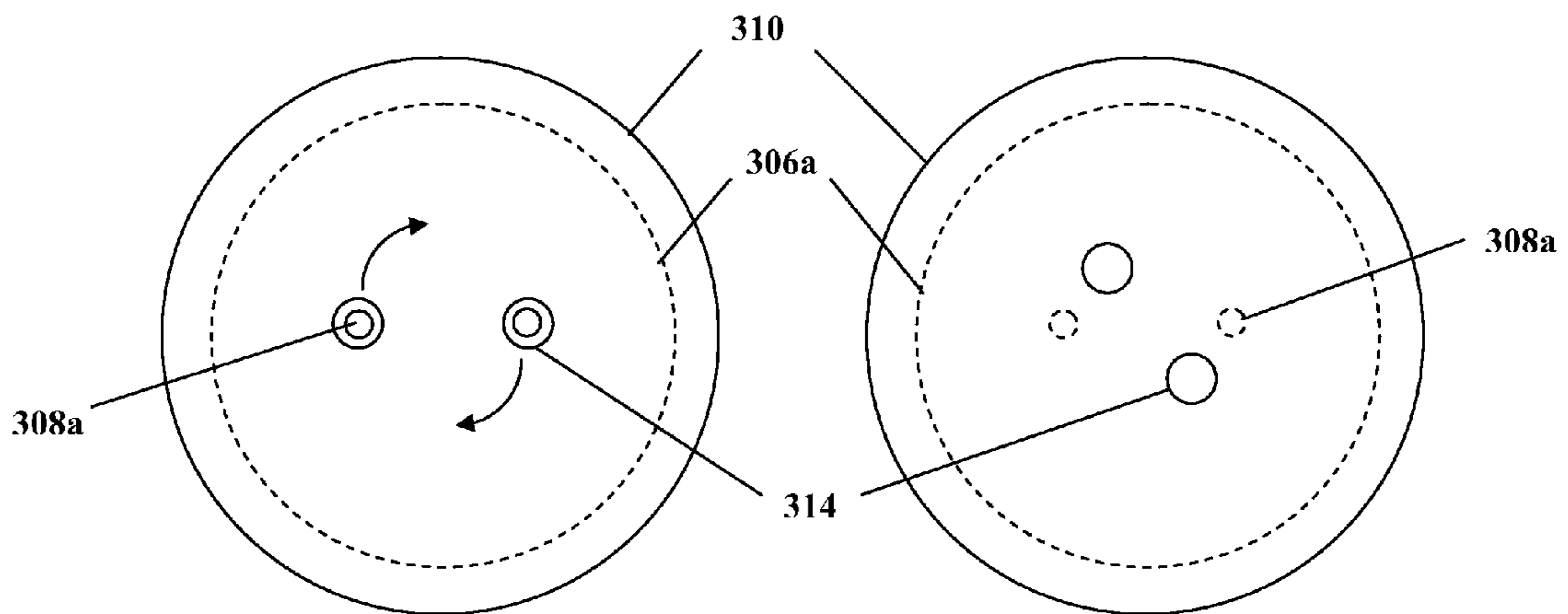


FIG. 3A1

FIG. 3B1

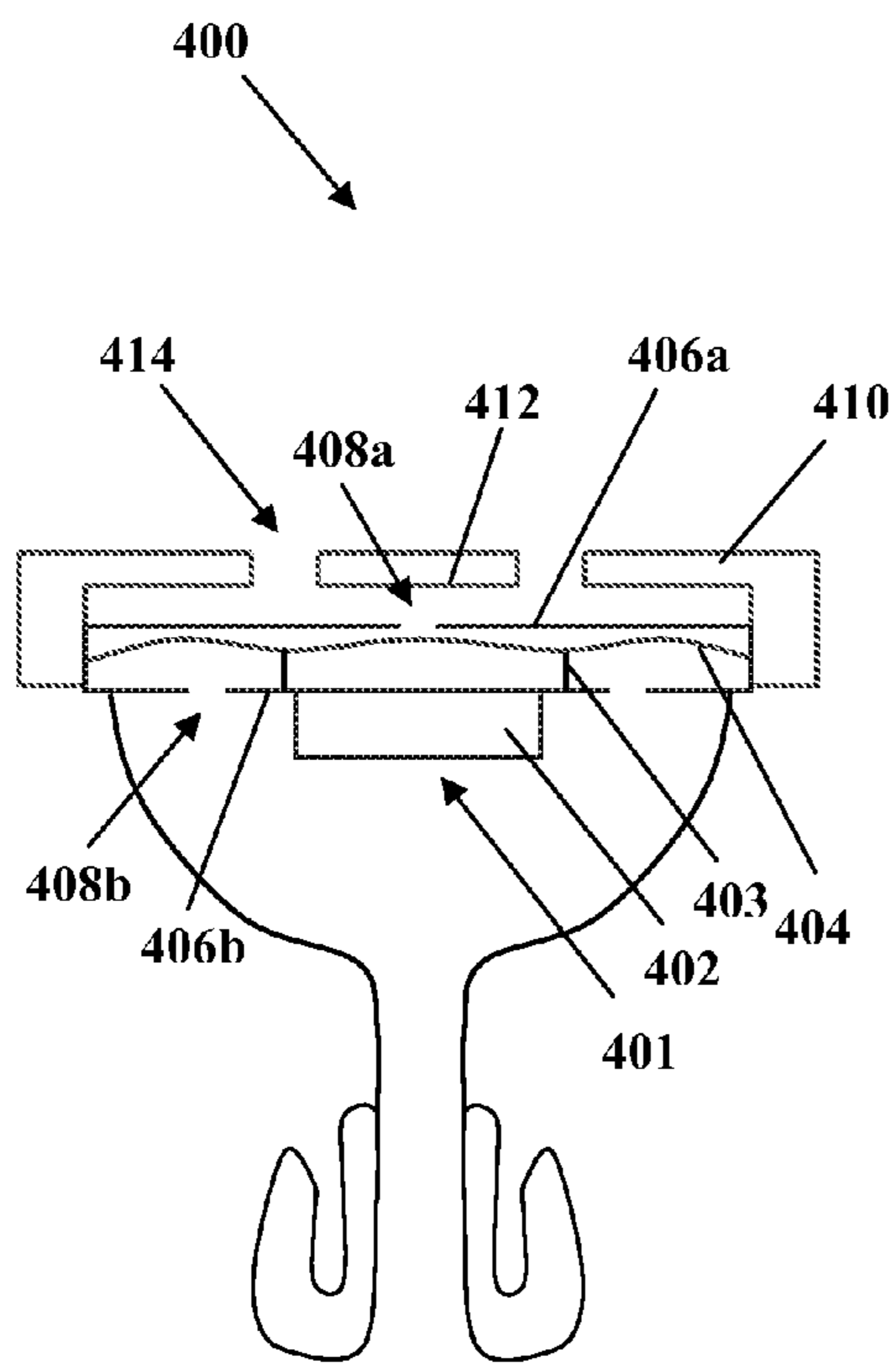


FIG. 4A

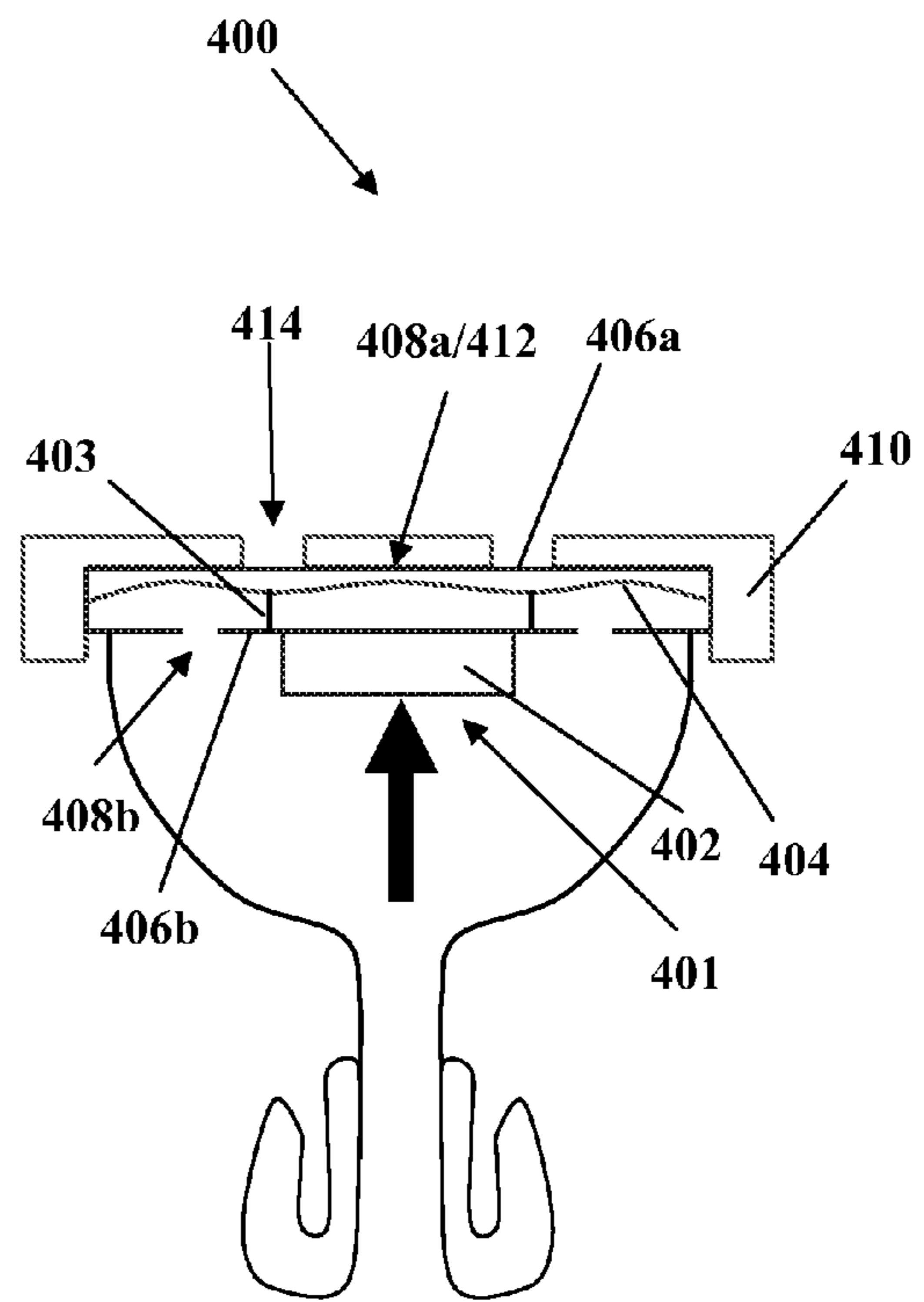


FIG. 4B

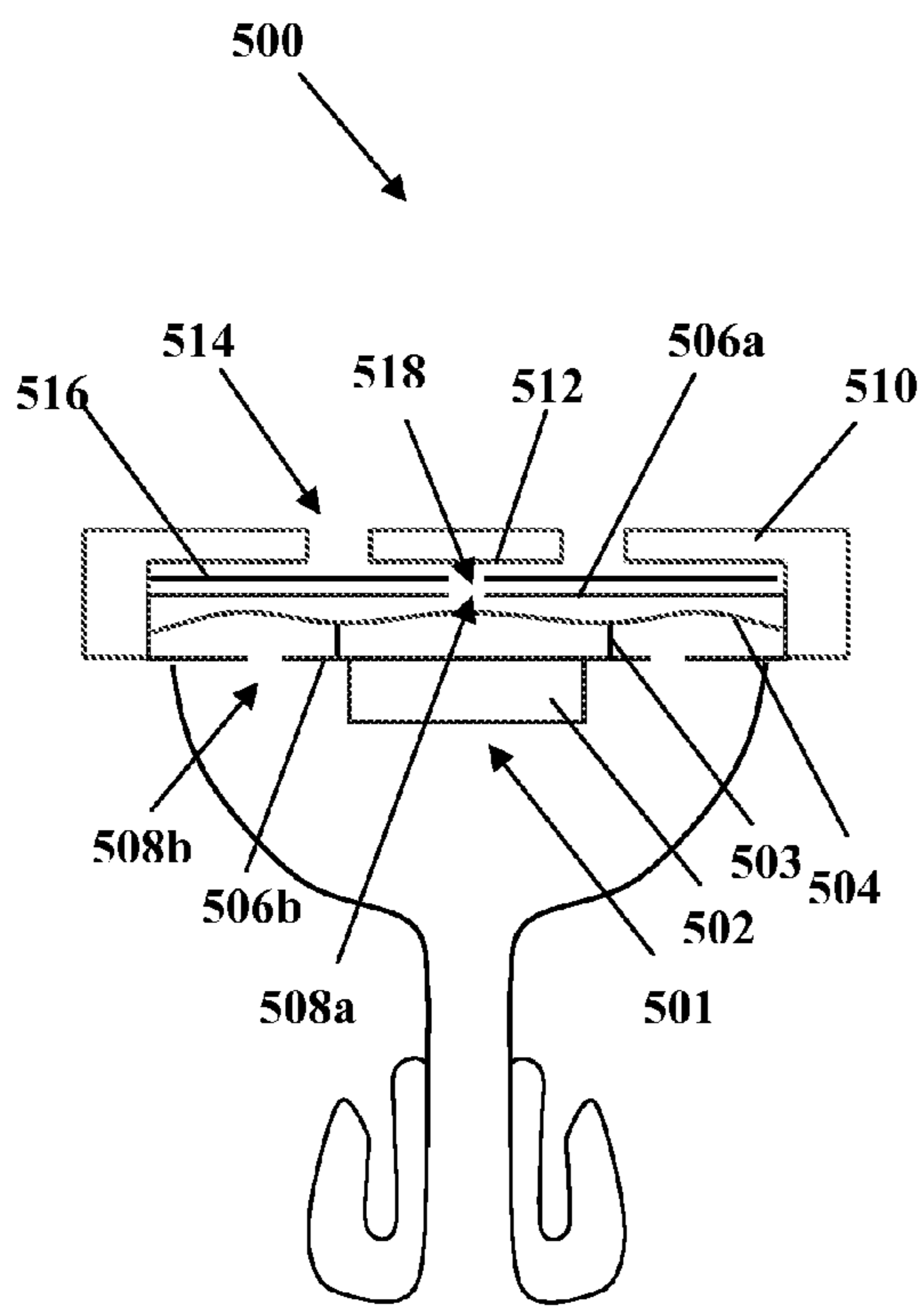


FIG. 5A

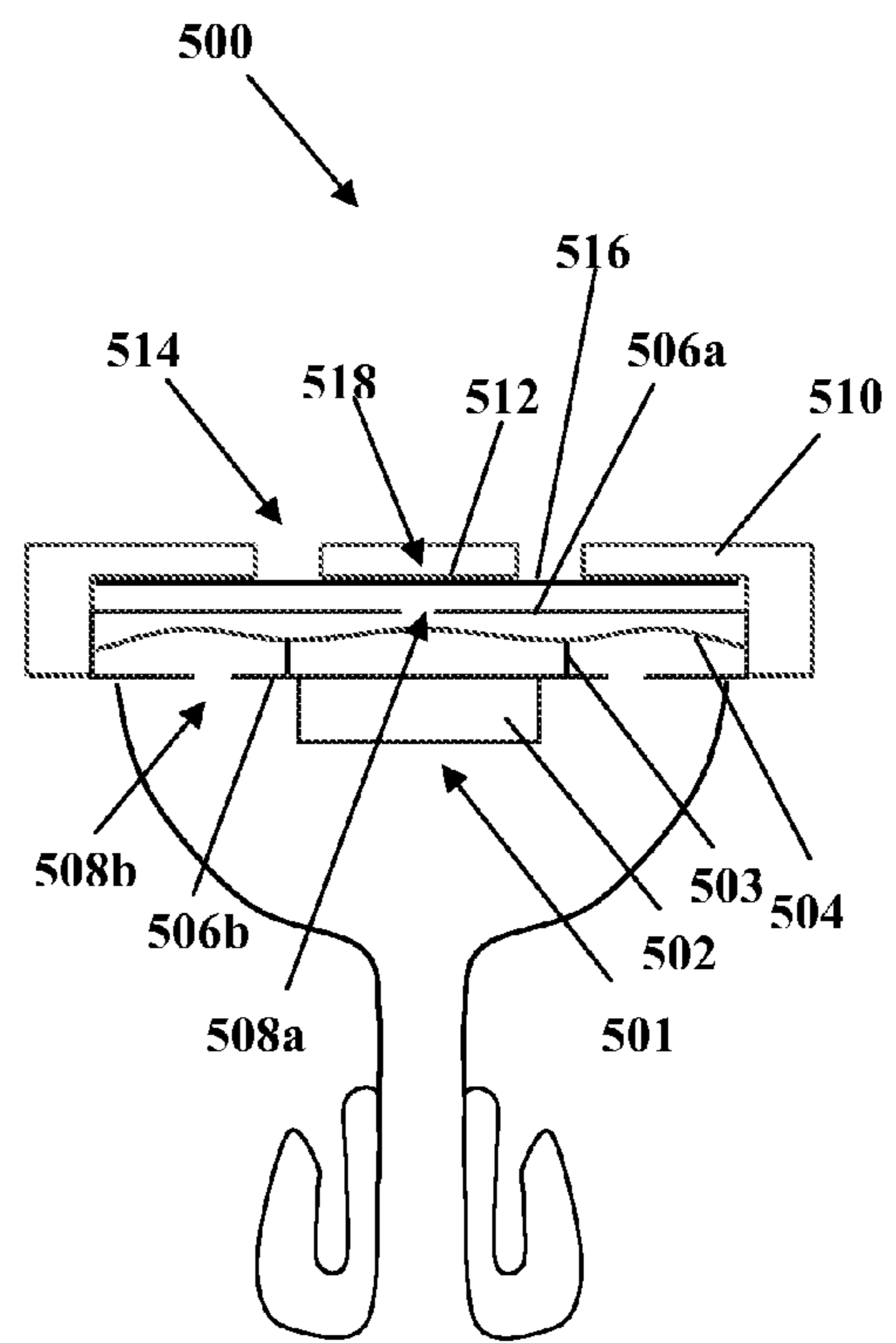


FIG. 5B

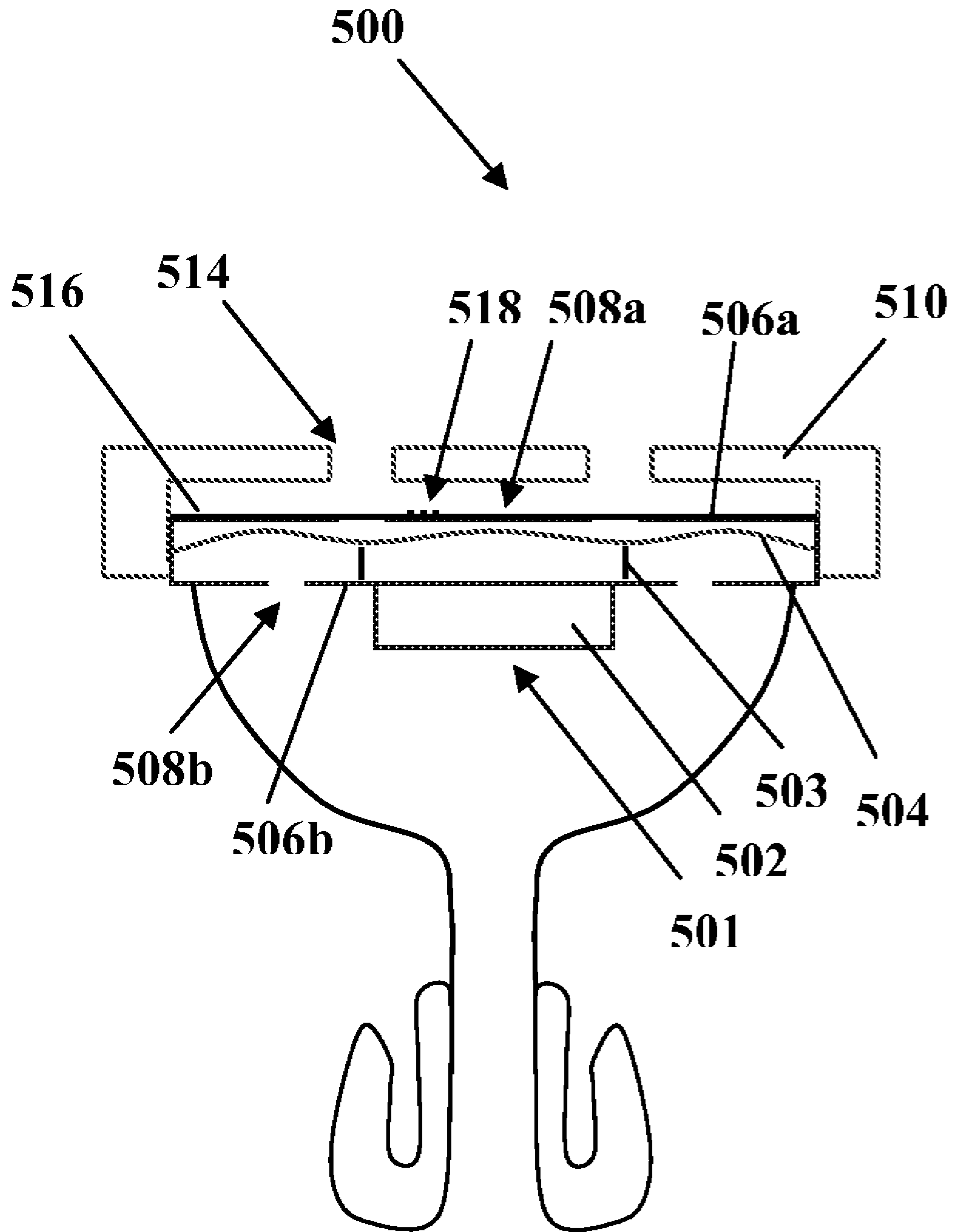


FIG. 5C

1

## DUAL MODE EARPHONE WITH ACOUSTIC EQUALIZATION

### BACKGROUND

#### 1. Field of the Invention

This invention generally relates to earphones and, more particularly, to an “in-the-ear” type of earphone with both a loose-fitting earbud and a canal-occluding earbud.

#### 2. Description of Related Art

One type of earphone, which can incorporate one or two earpieces for monaural or stereo listening, is known as an “in-the-ear” type earphone, which employs an earpiece that fits into the cavum area of a user’s ear.

Generally, in-the-ear type earphones can be divided into one of two categories: the loose-fitting category and the canal-occluding category. Loose-fitting earphones typically have larger diameter faceplates that contact the ear and are preferred for comfortable fit and open feel. Canal-occluding earphones (also known as isolation earphones or insert earphones) typically have a smaller form factor for fitting tightly in the ear canal and are preferred for higher sound quality and passive noise reduction. Users choose between these types of earphones depending on their individual needs and priorities.

However, the same person may have different needs at different times and in different situations. For example, one may prefer in an airport the loose-fitting mode to hear announcements but may prefer on the airplane the isolation mode. On other occasions, one might prefer the insert wearing style for its superior sound quality even in a quiet environment. In another example, one may prefer the loose-fitting mode when chewing or running as some people do not like their ears occluded during these activities but are not willing to give up listening to music or to miss handsfree phone calls.

A dual-mode earphone in which each side of a speaker is acoustically coupled to a different type of earbud is known. This type of earphone can work either in isolation mode with a canal-occluding earphone or in loose-fitting mode with a loose-fitting earphone. However, in prior dual-mode earphones, the audio quality has been compromised in one or both of the earbuds due to the lack of acoustic equalization capability.

Therefore, there is a need in the art for a dual-mode earphone that is simple to use and yet provides uncompromised sound quality for both modes of the earphone.

### SUMMARY

In accordance with the present invention, apparatus and methods are disclosed for providing acoustic equalization in a dual-mode earphone allowing for uncompromised sound quality in both modes of the earphone.

In one embodiment of the invention, a dual-mode earphone comprises a speaker with a diaphragm and a first earbud including at least one acoustic port operably coupled to the front of the diaphragm, and a cap in front of the speaker. The speaker or the cap is configured to move relative to the other for opening and closing the acoustic port. The earphone further includes a second earbud housing opposite the speaker including at least one acoustic port operably coupled to the back of the diaphragm.

In another embodiment of the invention, dual-mode earphone comprises a speaker with a diaphragm and a first earbud including at least one acoustic port operably coupled to the front of the diaphragm, a cap in front of the speaker, and an adjustable seal operably coupled between the speaker and the cap. The seal is configured to open and close the acoustic

2

port. The earphone further includes a second earbud housing opposite the speaker including at least one acoustic port coupled to the back of the diaphragm.

In yet another embodiment, a method for providing acoustic equalization in a dual-mode earphone is disclosed, the method comprising providing an earphone as described above and adjusting the cap or the speaker to open or close the acoustic port depending upon which of the first earbud or the second earbud housing is to be inserted into a user’s ear.

Advantageously, the present invention provides earphones and methods for use with improved audio quality and simple acoustic equalization.

These and other features and advantages of the present invention will be more readily apparent from the detailed description of the embodiments set forth below taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A-1B illustrate a rear view and a side view, respectively, and FIGS. 1C-1D illustrate perspective views, of a dual-mode earphone in accordance with an embodiment of the present invention.

FIGS. 2A-2B illustrate sectional views of the earphone of FIGS. 1A-1D including an adjustable cap in an open position and a closed position, respectively, in accordance with an embodiment of the present invention.

FIGS. 3A-3B illustrate sectional views and FIGS. 3A1-3B1 illustrate front views of an earphone including an adjustable twist cap in an open position and a closed position respectively, in accordance with another embodiment of the present invention.

FIGS. 4A-4B illustrate sectional views of an earphone including an adjustable speaker in an open position and a closed position, respectively, in accordance with another embodiment of the present invention.

FIGS. 5A-5C illustrate sectional views of an earphone including a movable seal in an open position and a closed position, respectively, in accordance with another embodiment of the present invention.

Embodiments of the present invention and their advantages are best understood by referring to the detailed description that follows. It should be appreciated that like reference numerals in different figures indicate similar or identical items. It should also be appreciated that the figures may not be necessarily drawn to scale.

### DETAILED DESCRIPTION

In all previous solutions known so far, the audio quality of a dual-mode earphone including a loose-fitting earpiece and a canal-occluding earpiece has been compromised because of the combination of two physical phenomena:

1. Whether the ear canal is occluded or un-occluded, the perception of sound always ensues from the acoustic pressure at the ear drum after being filtered by the free-field head-related transfer function (HRTF) of the unoccluded ear;
2. With a canal-occluding earbud, the sound pressure output of the speaker is proportional to the displacement of the speaker diaphragm, whereas in a loose-fitting earbud the sound pressure output of the speaker is proportional to the acceleration of the speaker diaphragm.

With existing dual-mode wearing solutions it is not possible to reconcile these phenomena. For the purpose of explaining this limitation, the operating frequency bandwidth will be divided into low and high frequency regions.



At low frequencies, for example less than about 800 Hz, the free-field HRTF is flat. This means that with insert earphones the speaker diaphragm's displacement must have the desired frequency response; and with loose-fitting earphones the speaker diaphragm's acceleration must have the desired frequency response. Obviously, the frequency response of the acceleration of one side of the diaphragm cannot be the same as the frequency response of the displacement of the other side of the diaphragm.

In other words, if the diaphragm's displacement is expressed as

$$x(t)=X\sin(\omega t)$$

then the diaphragm's acceleration becomes

$$a(t) = \frac{d^2 x}{dt^2} = -\omega^2 \cdot X \cdot \sin(\omega \cdot t) = -\omega^2 \cdot x(t)$$

That is, acceleration and displacement are out-of-phase; and the ratio of acceleration to displacement is equal to the transfer function of a second order high-pass filter.

At high frequencies, for example greater than about 800 Hz and less than about 7 kHz, the free-field HRTF of the unoccluded ear has a peak at approximately 3 kHz due to a resonance of the ear canal. Isolation earphones move this resonance to a higher frequency by occluding the ear canal. Therefore, for isolation earphones the frequency response of the displacement of the speaker diaphragm would preferably have a resonance peak at approximately 3 kHz. However, with loose-fitting earphones, the frequency response of the acceleration of the speaker diaphragm (i.e., that of the sound pressure output of the speaker) would preferably be flat over this frequency region. Obviously, opposite sides of the same diaphragm cannot satisfy both of these conditions.

It is noted that throughout this document, spatially relative terms, such as "in front" and "behind", may be used for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. For example, an acoustic structure "in front" of a speaker diaphragm may be a loose-fitting earbud, and an acoustic structure "behind" the speaker diaphragm may be a canal-occluding earbud. However, the configuration of earbuds may be different in other embodiments, and the perspective from which an element is in front or behind another element may be changed without altering the scope of the present invention. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

In accordance with the present invention, apparatus and methods are disclosed for providing acoustic equalization in a dual-mode earphone, thus allowing for uncompromised sound quality in both modes of the earphone.

Referring now to FIGS. 1A-1B, a rear view and a side view of a dual-mode earphone 100, respectively, are illustrated. FIGS. 1C-1D illustrate perspective views of dual-mode earphone 100. Earphone 100 may be used with an audio source, such as a telephone handset, a cellular phone, a personal

computer, a PDA, or a communication network. However, the invention is not limited to receiving a signal from a specific audio source. Furthermore, earphone 100 may be used for either monaural or stereo listening by applying earphone 100 to one or each ear of a user.

In one embodiment, earphone 100 includes a loose-fitting earbud 102 and a canal-occluding earbud housing 104 operably coupled to earbud 102 along an interface 106. The canal-occluding earbud housing may be sized to maximize fit into the recess of the user's ear and may seal to the inner features of the user's ear to block out external noise while directing sound from the transducer to the eardrum. The loose-fitting earbud may have a wider faceplate and fit more loosely and externally to the user's ear canal as compared to the canal-occluding earbud housing. In one example, loose-fitting earbud 102 and canal-occluding earbud housing 104 may have acoustic seal and wearing position characteristics in accordance with the "acoustically open (controlled leakage) intracocha" type of earphone and the "acoustically closed (minimum leakage) insert" type of earphone, respectively, as defined by the international standard for sound system equipment headphones and earphones, IEC 60268-7.

An internal speaker 201 (FIGS. 2A-2B) is housed within earbud 102 and used for both modes (loose-fitting and canal-occluding) of earphone 100. In one example, the internal speaker is an electro-acoustic speaker that receives audio signals from an audio signal source and may comprise a known type of electromagnetic, piezoelectric, or electrostatic type of driving element, or a combination thereof, or even some other form of driving element, for generating sound waves from the output face of the speaker and toward the cap. It is noted however that various applicable speakers may be used.

Speaker wires operably connect the speaker to an audio source. Speaker wires may extend outside of the earphone housing and can be protected inside a cable 110, which is made from a non-conductive material in one embodiment. Optionally, a cable boot 108 may be operably connected to the interface area between earbud 102 and earbud housing 104 where the cable enters the earphone and surrounds a portion of the cable adjacent to the outside of the earphone. The cable boot may be made from a hard or flexible material in one embodiment and protects the area of the cable just outside of earphone 100 from possible causes of disconnection, such as undesired bending and pulling that might cause a malfunction. The invention is not limited to using the aforementioned materials and the headset body, cable boot, and cable may be made of any protective material, such as rubber or polymer compounds.

Furthermore, a connector at the end of the speaker wires, such as a RJ-11 connector or a 2-3.5 mm plug, may operably connect the headset to an audio source, such as a telephone handset, cellular telephone, or a computer. In other embodiments, the invention may be incorporated in wireless earphones. In yet other embodiments, the dual-mode earphone of the present invention may be used in conjunction with a microphone to enable two-way voice communication by the user. In one example, the microphone may be operably enclosed in a pod below the dual-mode earphone in line with cable 110.

Referring now to FIGS. 2A-2B, sectional views of the dual-mode earphone of FIGS. 1A-1D along a line A-A (FIG. 1C) are illustrated in accordance with an embodiment of the present invention. Loose-fitting earbud 102 includes an adjustable cap 210, having a sealing surface 212 and an acoustic aperture 214, operably coupled in front of a speaker 201. Speaker 201 includes a magnet 202 and a voice coil 203

## 5

behind a diaphragm **204** housed between a front cover **206a** and a back cover **206b**. The front cover **206a** includes a front acoustic port **208a** and the back cover **206b** includes a back acoustic port **208b**. In this embodiment, acoustic aperture **214**, acoustic port **208a**, and acoustic port **208b** are not aligned to be along a straight path but this configuration is not necessarily so, as described in other embodiments below. It is also noted that in some embodiments, the speaker's magnet and coil may be arranged differently, or speaker **201** may not include a magnet or a voice coil.

In accordance with an embodiment of the present invention, adjustable cap **210** is movable between an open position in which acoustic port **208a** and acoustic aperture **214** are open for providing a pathway for sound (FIG. 2A), and a closed position in which acoustic port **208a** is sealed against sealing surface **212** and acoustic aperture **214** is sealed against the front cover **206a** (FIG. 2B). In one example, adjustable cap **210** is movable between an open position and a closed position by sliding means through which cap **210** slides over speaker **201**, or screwing means through which cap **210** includes internal threads and speaker **201** includes external threads for screwing or twisting cap **210** between an open position and a closed position.

In the sealed or closed position of the cap, all acoustic ports and apertures in front of diaphragm **204** are sealed and the mechanical impedance is that of the air spring from a small volume of air trapped between the diaphragm **204** and front cover **206a**. In the low frequency region (less than about 800 Hz), the mechanical impedance presented to the speaker is the compliance of this air spring; therefore the diaphragm displacement has a flat frequency response, and in the high frequency region (more than about 800 Hz and less than about 7 kHz), at some characteristic frequency depending on the effective area of the diaphragm, the trapped air volume and the moving mass of the speaker, the speaker diaphragm resonates with this air spring. This acoustically induced resonance results in a frequency response peak that matches that of the open-ear HRTF (approximately 3 kHz) which would be absent in the occluded ear canal. Thus, in the closed position of the ear cap (FIG. 2B), the structure in front of the speaker functions as an acoustic equalizer and the canal-occluding earbud **104** is optimized as an isolation earphone to be sealed to the ear canal. Passive attenuation is also provided to function as hearing protection in the isolation mode.

In the open or unsealed position of the cap (FIG. 2A), acoustic port **208a** and acoustic apertures **214** are open for passage of sound waves, and the speaker resonates at a sufficiently low frequency ideal for loose-fitting applications (free-air resonance). Above this frequency (for example about 250 Hz), the mechanical impedance presented to the speaker is its own moving mass, and the diaphragm acceleration therefore has a flat frequency response. The acoustically induced 3 kHz resonance is removed from the speaker because in the loose-fitting wearing style this resonance is present in the unoccluded ear canal. Thus, in the open position of the cap **210**, the loose-fitting earbud **102** is optimized as a non-occluding earbud to be inserted in the concha but not sealed to the ear canal.

Accordingly, adjustable cap **210** advantageously functions as an acoustic equalizer and allows the user to experience nearly the same frequency response in either wearing style as when the earbuds are separately manufactured.

Referring now to FIGS. 3A-3B and 3A1-3B1, sectional views and front views of a headset **300** (similar to sectional views taken along a line A-A in FIG. 1C for example) are illustrated in accordance with another embodiment of the present invention. Cap **310** is movably coupled to speaker **301**

## 6

such that acoustic apertures **314** are aligned with acoustic ports **308a** in the open or unsealed position and not aligned in the closed or sealed position.

Similar to the embodiment described above with respect to FIGS. 2A-2B, a loose-fitting earbud of earphone **300** includes an adjustable cap **310**, having a sealing surface **312** and an acoustic aperture **314**, operably coupled in front of a speaker **301**. Speaker **301** includes a magnet **302** and a voice coil **303** behind a diaphragm **304** housed between a front cover **306a** and a back cover **306b** (again it is noted that in some embodiments, speaker **301** may not include a magnet or a voice coil). The front cover **306a** includes a front acoustic port **308a** and the back cover **306b** includes a back acoustic port **308b**.

As noted above, in this embodiment, acoustic aperture **314** and acoustic port **308a** are aligned in the open position and not aligned in the closed position to thereby seal the acoustic ports and apertures in front of the diaphragm. Adjustable cap **310** is movable between an open position in which acoustic port **308a** and acoustic aperture **314** are open for providing a pathway for sound (FIGS. 3A and 3A1), and a closed position in which acoustic port **308a** is sealed against sealing surface **312** and acoustic aperture **314** is sealed against the front cover **306a** (FIGS. 3B and 3B1). In one example, adjustable cap **310** is movable between an open position and a closed position by twisting cap **310** over speaker **301** such that apertures **314** and ports **308a** are moved between an aligned position (FIG. 3A) and an un-aligned position (FIG. 3B1).

Similar to the embodiment described above, in the sealed or closed position of the cap, all acoustic ports and apertures in front of diaphragm **304** are sealed and the structure in front of the speaker functions as an acoustic equalizer and the canal-occluding earbud is optimized as an isolation earphone to be sealed to the ear canal.

In the open or unsealed position of the cap, acoustic port **308a** and acoustic apertures **314** are open for passage of sound waves, and the speaker resonates at a sufficiently low frequency ideal for loose-fitting applications (free-air resonance). Thus, in the open position of the cap **310**, the loose-fitting earbud is optimized as a non-occluding earbud to be inserted in the concha but not sealed to the ear canal.

Accordingly, adjustable cap **310** advantageously functions as an acoustic equalizer and allows the user to experience nearly the same frequency response in either wearing style as when the earbuds are separately manufactured.

Referring now to FIGS. 4A-4B, sectional views of a headset **400** (similar to sectional views taken along a line A-A in FIG. 1C for example) are illustrated in accordance with another embodiment of the present invention. In this embodiment, cap **410** is fixed relative to the housing but speaker **402** is movable, and the opening and closing of the ports and apertures may be otherwise similar to the previous embodiment described above with respect to FIGS. 2A-2B. A loose-fitting earbud includes a fixed cap **410**, with a sealing surface **412** and an acoustic aperture **414**, operably coupled in front of an adjustable speaker **401**. Adjustable speaker **401** includes a magnet **402** and a coil **403** behind a diaphragm **404** housed between a front cover **406a** and a back cover **406b** (again it is noted that in some embodiments, speaker **401** may not include a magnet or a voice coil). Front cover **406a** includes an acoustic port **408a** and back cover **406b** includes an acoustic port **408b**.

In accordance with an embodiment of the present invention, adjustable speaker **401** is movable between an open position in which acoustic port **408a** and acoustic aperture **414** are open for passage of sound (FIG. 4A), and a closed position in which acoustic port **408a** is sealed against sealing surface **412** and acoustic aperture **414** is sealed against front

cover **406a** (FIG. 4B). In a preferred embodiment of the invention, speaker **402** may be a dynamic speaker, and may be movable by various means and methods, such as a button actuator or an electric motor.

Similar to the embodiment described above, in the sealed or closed position of the cap, all acoustic ports and apertures in front of diaphragm **404** are sealed and the structure in front of the speaker functions as an acoustic equalizer and the canal-occluded earbud is optimized as an isolation earphone to be sealed to the ear canal.

In the open or unsealed position of the cap, acoustic port **408a** and acoustic apertures **414** are open for passage of sound waves, and the speaker resonates at a sufficiently low frequency ideal for loose-fitting applications (free-air resonance). Thus, in the open position of the cap **410**, the loose-fitting earbud is optimized.

Accordingly, adjustable speaker **401** advantageously functions as an acoustic equalizer and allows the user to experience nearly the same frequency response in either wearing style as when the earbuds are separately manufactured.

Referring now to FIGS. 5A-5C, sectional views of a headset **500** (similar to sectional views taken along a line A-A in FIG. 1C, for example) are illustrated in accordance with another embodiment of the present invention. In this embodiment, cap **510** and speaker **501** may be fixed and a separate movable seal **516** may be operably coupled between cap **510** and speaker **501**. A loose-fitting earbud includes a fixed cap **510**, with a sealing surface **512** and an acoustic aperture **514**, operably coupled in front of an adjustable speaker **501**. Speaker **501** includes a magnet **502** and a coil **503** behind a diaphragm **504** housed between a front cover **506a** and a back cover **506b** (again it is noted that in some embodiments, speaker **501** may not include a magnet or a voice coil). Front cover **506a** includes an acoustic port **508a** and back cover **506b** includes an acoustic port **508b**. In this embodiment, seal **516** includes an aperture **518** aligned with acoustic port **508a**.

In accordance with an embodiment of the present invention, adjustable seal **516** is movable between an open position in which acoustic port **508a** and acoustic aperture **514** are open for passage of sound (FIG. 5A), and a closed position in which acoustic aperture **514** is sealed (FIG. 5B) by moving seal **516** against sealing surface **512** of cap **510**. Acoustic port **508a** may remain open in this embodiment. It is noted that in other embodiments, acoustic port **508b** may be sealed and acoustic aperture **514** left open in the closed position of seal **516** by not having the aperture of seal **516** aligned with acoustic port **508a** and moving seal **516** against front cover **506a** (FIG. 5C). In yet other embodiments, both the acoustic ports **508a** and apertures **514** may be sealed by having seal **516** tightly fit between cap **510** and speaker **501** and including seal apertures **518** which are not aligned with the ports or apertures when the seal is moved to the closed position. In yet other embodiments, the seal may include a plurality of apertures aligned with both the acoustic apertures and acoustic ports in the open position, and unaligned apertures in the closed position to seal both the acoustic apertures and the acoustic ports. Seal **516** may be movable by various means and methods, such as a twistable or slidable plate (including apertures) between the cap and speaker.

Thus, in the sealed or closed position of the seal, some (or all) acoustic ports and/or apertures in front of diaphragm **504** are sealed and the structure in front of the speaker functions as an acoustic equalizer and the canal-occluded earbud is optimized as an isolation earphone to be sealed to the ear canal.

In the open or unsealed position of the seal, acoustic port **508a** and acoustic apertures **514** are open for passage of sound waves, and the speaker resonates at a sufficiently low

frequency ideal for loose-fitting applications (free-air resonance). Thus, in the open position of the seal, the loose-fitting earbud is optimized as a non-occluding earbud to be inserted in the concha but not sealed to the ear canal.

Accordingly, the adjustable seal **516** advantageously functions as an acoustic equalizer and allows the user to experience nearly the same frequency response in either wearing style as when the earbuds are separately manufactured.

Advantageously, the present invention discloses a single earphone that provides high comfort with one wearing mode and high performance with another wearing mode. Furthermore, the present invention optimizes both modes of a dual-mode earphone with a simple acoustic equalizer that allows the user to experience nearly the same frequency response in either wearing style as when the earbuds are separately manufactured. Thus, the earphone of the present invention may provide the best possible acoustic quality (e.g., bass response) with both wearing styles and the user can choose a wearing style relatively independent from an acoustic response. For example, the present invention allows the user to select a wearing style based on comfort, ambient noise isolation, stability, and appearance instead of sound quality.

The above-described embodiments of the present invention are merely meant to be illustrative and not limiting. It will thus be obvious to those skilled in the art that various changes and modifications may be made without departing from this invention in its broader aspects. For example, different configurations and numbers of apertures of the cap and ports of the speaker covers are possible without departing from the scope of the present invention. Therefore, the appended claims encompass all such changes and modifications as falling within the true spirit and scope of this invention.

I claim:

1. A dual-mode earphone, comprising:

a first earbud including:

a speaker with a diaphragm and at least one acoustic port in front of the diaphragm, and

a cap in front of the speaker, the speaker or the cap configured to move relative to the other for opening and closing the acoustic port; and

a second earbud housing operably coupled to the first earbud opposite the speaker.

2. The earphone of claim 1, wherein the first earbud is a loose-fitting earbud and the second earbud housing is a canal-occluding earbud housing.

3. The earphone of claim 1, wherein the cap is adjustable and configured to open and close the acoustic port against a surface of a fixed speaker.

4. The earphone of claim 1, wherein the cap is adjustable via screwing means or sliding means.

5. The earphone of claim 1, wherein the cap includes at least one aperture and at least one sealing surface that can substantially seal the acoustic port.

6. The earphone of claim 5, wherein the at least one aperture is aligned with the acoustic port or not aligned with the acoustic port.

7. The earphone of claim 1, wherein the speaker is adjustable and configured to open and close the acoustic port against a surface of a fixed cap.

8. The earphone of claim 1, wherein the speaker includes at least one acoustic port behind the diaphragm and in front of the second earbud housing.

9. The earphone of claim 1, wherein the speaker and the cap are both adjustable relative to one another.

10. A dual-mode earphone, comprising:

a first earbud including:

**9**

a speaker with a diaphragm and at least one acoustic port  
 in front of the diaphragm,  
 a cap in front of the speaker, and  
 an adjustable seal operably coupled between the speaker  
 and the cap, the seal configured to open and close the  
 acoustic port; and  
 a second earbud housing operably coupled to the first ear-  
 bud opposite the speaker.

**11.** The earphone of claim **10**, wherein the first earbud is a  
 loose-fitting earbud and the second earbud housing is a canal-  
 occluding earbud housing.

**12.** The earphone of claim **10**, wherein the seal is adjustable  
 via screwing means or sliding means.

**13.** The earphone of claim **10**, wherein the cap includes at  
 least one aperture which can be closed by the seal.

**14.** The earphone of claim **13**, wherein the at least one  
 aperture is aligned with the acoustic port or not aligned with  
 the acoustic port.

**15.** The earphone of claim **10**, wherein the speaker includes  
 at least one acoustic port behind the diaphragm and in front of  
 the second earbud housing.

**16.** A method for providing acoustic equalization in a dual-  
 mode earphone, the method comprising:  
 providing a dual-mode earphone, including:

**10**

a first earbud having a speaker with a diaphragm and at  
 least one acoustic port in front of the diaphragm, and  
 a cap in front of the speaker, and  
 a second earbud housing operably coupled to the first  
 earbud opposite the speaker; and  
 adjusting the cap or the speaker to open or close the acous-  
 tic port depending upon which of the first earbud or the  
 second earbud housing is to be inserted into a user's ear.

**17.** The method of claim **16**, further comprising opening  
 the acoustic port when the first earbud is to be inserted or  
 closing the acoustic port when the second earbud housing is to  
 be inserted.

**18.** The method of claim **16**, wherein adjusting the cap  
 includes turning the cap or sliding the cap.

**19.** The method of claim **16**, wherein adjusting the cap to  
 close the acoustic port includes interfacing a sealing surface  
 on the cap with the acoustic port.

**20.** The method of claim **16**, further comprising transmit-  
 ting sound through the first earbud via the acoustic port in  
 front of the diaphragm or transmitting sound through the  
 second earbud housing via an acoustic port behind the dia-  
 phragm.

\* \* \* \* \*